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ORIGINAL RESEARCH

RELIABILITY AND EXPLORATION OF THE SIDE-LYING THORACO-LUMBAR ROTATION MEASUREMENT (STRM)

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ABSTRACT

Study Design: Clinical Measurement, Reliability, Descriptive Study

Objectives: To establish intrarater and interrater reliability of the Side-lying Thoraco-lumbar Rotation Measurement (STRM) and to explore frequencies and magnitude of rotational differences that exist in various musculoskeletal conditions.

Background: Limitation in thoracic rotation could lead to increased motion at adjacent areas (i.e., shoulders and low back). This could potentially lead to excessive strain and subsequent injury from repetitive stress. Currently, there is no well-established method to reliably measure and objectively quantify thoraco-lumbar spine rotation.

Methods: Intrarater reliability was assessed by a single investigator performing three STRM measurements on 10 participants on two consecutive days. Interrater reliability was assessed by two independent examiners, performing the STRM on 30 participants. Reliability was assessed using the intraclass correlation coefficient (ICC) statistic. To explore the incidence and magnitude of side-to-side thoraco-lumbar rotation differences, the STRM was measured on 156 participants of various musculoskeletal conditions.

Results: The intrarater reliability of the STRM was excellent (ICC = .94). The interrater reliability was good (ICC = .88). Fifty four percent of the sample exhibited greater than a 10% side-to-side difference in the STRM while twenty percent exhibited greater than a 20% side-to-side difference.

Conclusion: The STRM can be used as a reliable and objective method to quantify thoraco-lumbar spine rotation. It also appears that a large percentage of patients with varied musculoskeletal complaints may have greater than a 10-20% asymmetry in spinal rotational movement. Future research is needed to determine the clinical applicability and relevance of these findings.

Level of Evidence: 4

Key words: Thoraco-lumbar rotation, reliability

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This research was conducted at the United States Military Academy, West Point, NY. At the time of the research, Lieutenant Commander Iveson was completing a post professional sports medicine physical therapy residency under the mentorship of Dr Gerber as well as completing his DScPT in Physical Therapy from Baylor University, Waco TX. The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the US Navy, US Army or the Department of Defense.
This Study was approved by the Institutional Review Board at Keller Army Community Hospital.

INTRODUCTION

The body is a complex system of interrelated parts, dependently linked together for optimal performance. Either excessive movement or lack of movement in one area can greatly hinder the performance of another area. Rehabilitation is often geared toward achieving a proper balance of strength and motion of the injured anatomical part and surrounding structures. Objectively assessing joint range of motion (ROM) and subsequent therapeutic intervention aimed at correcting existing impairments are essential skills used by rehabilitation experts.

While the thoracic spine is a key contributor to functional rotation in the human body, reliably measuring and objectively quantifying thoracic rotation is not straightforward. Nonetheless, research would suggest that treatment directed at the thoracic spine leads to favorable results for several musculoskeletal conditions. Cleland et al.[6] showed that thrust mobilization/manipulation to the mid thoracic spine led to reductions in pain and disability in people with neck pain. Bang et al.[2] and Bergman et al.[3] demonstrated that directing manual therapy intervention at the shoulder girdle, ribcage, thoracic spine and cervical spine led to favorable outcomes for treating shoulder dysfunction. Although the results reported by these authors are favorable, it is unclear if the improvements were due to an increase in rotational motion of the thoracic spine. The inability to establish a cause and effect between increasing thoracic ROM and obtaining a reduction of symptoms in these studies may be due in part to the absence of a feasible and reliable method to assess rotational movement of the thoracic spine.

The authors of the current study were able to find only one study that reliably measured thoracic rotation in conjunction with a group of symptomatic patients. Al-Eisa et al.[1] quantified thoracic spine rotation limitations in a group of patients who were symptomatic with regard to low back pain. They also determined that a significant correlation existed between unilateral SI joint dysfunction and contralateral limitation in thoracic spine rotation as well as bilateral thoracic spine rotational limitations in symptomatic back pain patients. The measurement techniques used to assess thoracic rotation, however, were elaborate and not practical for use in the clinical setting.

Other clinically viable techniques to assess spinal rotation have been developed and tested but have demonstrated poor inter-rater and intra-rater reliability.[5] Currently, there is no well-established and routinely utilized clinically viable method to reliably measure and objectively quantify thoracic rotation. Due to the difficulty of measuring thoracic spine rotation in isolation, it is more clinically feasible to include the minimal rotational contributions of the lumbar spine[7] into a global trunk rotation measurement. The primary purpose of this study therefore was to establish intrarater and interrater reliability of the Side-lying Thoraco-lumbar Rotation Measurement (STRM) using a standard physical therapy bubble inclinometer. The authors hypothesized that thoraco-lumbar rotation could be reliably measured using the STRM between clinicians with an ICC $>$ 0.80. A secondary purpose was to explore frequencies and magnitude of thoraco-lumbar rotational differences that exist in patients presenting with various musculoskeletal conditions of the spine, upper, and lower extremities.

METHODS

Participants:

Participants included males and females between the ages of 17 and 24 who sought medical care in a direct access, sports-medicine physical therapy clinic. Participants who reported they had a new musculoskeletal complaint of an upper or lower extremity or of the spine were invited to participate. Potential participants were initially screened by one co-investigator (JPG) to determine if they met the basic criteria for the study. Participants signed an informed consent and HIPPA addendum prior to participation. This study was approved by the Institutional Review Board at Keller Army Community Hospital.

Procedures:

The STRM technique is described in detail in Table 1 and illustrated in Figure 1. To assess intrarater reliability the primary investigator performed the STRM on 10 participants over two consecutive days. Each side was measured 3 times, alternating between the left and right. The 3 measurements were averaged for analysis. This method required the participant to flip over from left to right side several times during the course of the measurement. After the intrarater reliability was assessed, the measurement process

Table 1. *Steps for performing The Side-lying Trunk Rotation Measurement (STRM).*
1) Starting in the supine position, the subject log rolls onto his or her side and flexes the hips and knees to 90 degrees (90/90 position). The subject's trunk, rib cage, scapula, and posterior deltoid (not the lateral shoulder) should be in contact with the treatment table.
2) The subject places his or her treatment table side hand on the ipsilateral knee and the opposite hand on its ipsilateral hip.
3) The clinician "zeroes" a bubble inclinometer for a starting point of 0 degrees rotation perpendicular to the treatment table
4) Standing behind the patient, the clinician places his or her hand on the posterior aspect of the upper calves for stabilization to prevent the knees from separating during the measurement.
5) The clinician places the inclinometer across the subject's sterno-clavicular joint using the sterno-clavicular notch as the standard reference point.
6) As the subject rotates the trunk back onto the treatment table posteriorly to approximate the scapulae to the table, the measurement is recorded.

was streamlined to make it less cumbersome and therefore more clinically feasible. To assess interrater reliability, two independent examiners performed the STRM on 30 participants by taking two consecutive STRMs on each side and recording the average for each side. Two measurements were taken for the interrater reliability portion of this study, because reliability results were virtually equal when averaging 2 versus all 3 measurements during the intrarater portion. The two investigators alternated the order in which they performed the measurements and were blinded to the results of the other investigator.

To explore the frequency and magnitude of side-to-side thoraco-lumbar rotation differences, the same investigator (BDI) performed the STRM on 156 participants as a screening measurement. The STRM for both the right and left sides were recorded. The difference between the 2 sides as well as the percentage difference between sides were calculated.

Figure 1. *The Sidelying Thoracic Rotation Measurement (STRM), start and finish positions. Note placement of inclinometer.*

Table 2. *STRM Thoraco-lumbar rotation measurements, listed by symptomatic region.*

Symptomatic Region	Mean Right Rotation (degrees)*	Mean Left Rotation (degrees)*
Shoulder (n=23)	52.8±7.9	51.8±8.9
Mid back (n=6)	51.4±8.7	50.9±9.8
Low back (n=11)	53.5±7.6	53.4±6.5
Hip (n=9)	50.7±9.0	49.1±13.2
Knee (n=49)	60.2±9.5	58.2±10.9
Leg/Ankle/Foot (n=31)	53.1±8.2	50.8±8.9
†Other (n=27)	54.0±11.7	52.3±12.3
Total (N=156)	**55.2±9.7**	**53.6±10.7**

* Values are mean ± SD
†Elbow, wrist, contusions

Table 3. *Side-to-side STRM Thoraco-lumbar rotation measurement differences, listed by symptomatic region.*

Symptomatic Region	Mean Difference (degrees)*	Mean Difference (percent)*
Shoulder (n=23)	6.4±4.1	11.8±8.2
Mid back (n=6)	7.8±7.0	12.8±11.0
Low back (n=11)	5.5±3.9	9.5±6.6
Hip (n=9)	7.1±5.8	14.0±12.7
Knee (n=49)	6.8±4.6	11.2±7.9
Leg/Ankle/Foot (n=31)	8.1±4.8	14.5±8.5
†Other (n=27)	8.2±5.5	14.7±9.6
Total (N=156)	**7.2±4.9**	**12.7±8.7**

* Values are mean ± SD
†Elbow, wrist, contusions

Table 4. *Frequency of STRM Side-to-side Thoraco-lumbar rotation differences greater than 10% and 20%.*

Symptomatic Region	Frequency of Subjects with > 10 % SSD Number (percent)	Frequency of Subjects with > 20 % SSD Number (percent)
Shoulder (n=23)	13/23 (56.5%)	3/23 (13%)
Mid back (n=6)	2/6 (50%)	2/6 (50%)
Low back (n=11)	5/11 (45.5%)	0.0
Hip (n=9)	5/9 (56.6%)	1/9 (11.1%)
Knee (n=49)	23/49 (46.9%)	9/49 (18.4%)
Leg/Ankle/Foot (n=31)	19/31 (61.3%)	8/31 (25.8%)
*Other (n=27)	16/27 (59.3%)	7/27 (25.9%)
Total (N=156)	**83/156 (54.8%)**	**31/156 (20%)**

Abbreviations: SSD, Side-to-side difference
*Elbow, wrist, contusions

Applicable group means and standard deviations were determined. The affected body part were provided by the attending physical therapist after completion of the medical examination.

Statistical analysis:

The intrarater and interrater reliability assessments of the STRM were performed using the intraclass correlation coefficient (ICC) statistic. Descriptive statistics were used to organize, summarize, and report the data. Frequencies and the magnitude of rotation differences that were observed in various musculoskeletal conditions were calculated. Data was analyzed using SPSS Statistics v. 18.0 (SPSS, Inc., Chicago, IL).

RESULTS

Reliability

One hundred fifty-six participants (131 males, 25 females, mean ages of 19.8 ± 1.7 and 19.2 ± 1.5 years respectively) participated in the study. The mean STRM across the sample was 55.2 ± 9.7 degrees on the right and 53.6 ± 10.7 degrees on the left. The intrarater reliability of the STRM on 10 participants was excellent (ICC = .94) (2,1). The interrater reliability of the STRM on 30 participants between two clinicians was good (ICC = .88) (2,1). This value was similar for both left (ICC = .87) and right (ICC = .89) side measurements.

Side-to-side Thoraco-lumbar Rotation Differences

The mean STRM was fairly consistent across symptomatic regions of the body (Table 2). There was a mean side-to-side thoraco-lumbar rotation difference of 7.2 ± 4.9 degrees or 12.7 ± 8.7%. The side-to-side difference assessed by the STRM was fairly consistent across symptomatic regions of the body (Table 3). Eighty-three of 156 (54.8%) had a 10% or greater side-to-side difference in the STRM while thirty-one of 156 (20%) had a 20% or greater difference in the STRM (Table 4).

DISCUSSION

The primary finding of this study was that the STRM can be used reliably to assess thoraco-lumbar spine rotation. There was excellent intrarater reliability and good interrater reliability. Also, results suggest that a large percentage of patients with varied musculoskeletal complaints may have greater than a 10-20% asymmetry in spinal rotational movement.

The anatomy of the thoracic spine in the presence of the ribcage presents challenges in assessing normal movement as well as clinically measuring side-to-side rotational differences. One difficulty is solely measuring thoracic rotation without lumbar rotation. This is analogous with the difficulty of measuring glenohumeral flexion without motion contributions of the scapulothoracic joint. While the STRM does incorporate both the thoracic and lumbar spine rotation into one measurement the thoracic rotational component is much greater than the lumbar rotational component.[4, 7] The mean values of thoraco-lumbar rotation found in this study are comparable to other reported values.[4, 7] Boyling et al.[4] reported that the range of axial rotation in the mid thoracic spine is 5-10 degrees per segment based on cadaveric studies and in vivo measurements. Magee reports that total thoracic spine rotational range of motion (left and right together) is 35-50 degrees while total lumbar spine rotational range of motion (left and right together) is 3-18 degrees.[7] Using the per segment measurements reported by Boyling et al.[4], it appears that the STRM numbers reported in the present study compare favorably. This would suggest that the STRM has reasonable validity as an objective measure in assessing thoraco-lumbar rotation. The STRM may prove valuable to clinicians and researchers as it provides a clinically feasible, objective, and reliable method to assess thoraco-lumbar rotation.

When looking at side-to-side differences in the STRM, the authors were surprised by two primary findings. First, approximately 1 in every 2 participants had a 10% side-to-side difference in the STRM while 1 in 5 participants had a 20% side-to-side difference. Second, the authors anticipated participants with complaints of pain in close proximity to the thoracic spine, such as the shoulder complex, to have greater side-to-side differences in the STRM compared to those with lower leg, wrist, or other more distant complaints. The significance of finding side-to-side differences or bilateral limitations in thoraco-lumbar rotation is unknown. There is no way to determine from this study whether the observed differences were due simply to handedness, specific sport participation, or other personal habits. On the other hand, it is possible that the observed differences were due to a compensation or protective reaction to a previous injury that contributed to a decrease in spinal motion and ultimately lead to spinal rotation asymmetry. A previously unknown limitation of spinal rotation could be a primary culprit in a patient's underlying complaint. It is clear that in this sample of patients with musculoskeletal complaints a 10-20% asymmetry was observed. While it remains unclear what magnitude of a thoraco-lumbar rotational difference would be clinically meaningful, it is conceivable that a 10-20% asymmetry in spinal rotation could alter musculoskeletal biomechanics, efficiency, and function. The importance of this asymmetry might be more fully understood using the regional interdependence model.

The regional interdependence model refers to the concept that seemingly unrelated impairments in remote anatomical regions may contribute to or be associated with the patient's primary complaint in another region of the body.[9] Biomechanically, a decrease in motion at one segment of the body (i.e., thoracic spine) may lead to an increase in motion at adjacent segments of the body (i.e., shoulders or low back) thus potentially leading to increased strain and injury. While treatment directed at reducing load on the symptomatic region may lead to a decrease in patient symptoms, failure to correct the underlying impairment may result in only a temporary decrease in these symptoms and a recurrent problematic condition. Further research geared toward assessment of the STRM and subsequent therapeutic manual therapy and exercises to address limitations on people with various diagnoses may assist in realizing the potential benefit of this STRM technique for examination as well as the efficacy of any described intervention approaches.

One manual therapy treatment used to address an existing thoraco-lumbar rotation limitation is termed the "thoracic sequence" (Table 5).[8] The thoracic sequence was devised as a method to treat deficits in thoraco-lumbar rotation. The hip joint, iliotibial band, thoracic spine, rib cage, pectoralis minor and latissimus dorsi muscles may each potentially limit thoraco-lumbar rotation. It is unknown to what extent each component may contribute to limiting spinal rotation or whether the order of the intervention is important. Rather, the thoracic sequence provides a framework and a systematic step-by-step approach in addressing each of these areas. By re-assessing thoraco-lumbar rotation after each step of the sequence, the tester is able to determine where in the biomechanical chain restrictions exist, which in turn may help focus the treatment intervention. The authors are currently conducting research in this area to further test this technique and its effect on increasing thoraco-lumbar rotation as measured by the STRM.

Table 5. *The Authors proposed Thoracic Intervention Sequence. A step-by-step method used to improve existing functional restrictions in thoraco-lumbar rotation.[8] The steps are performed in order with the patient in the side-lying position.*
1. **Iliotibial Band Release:** A soft tissue mobilization technique utilizing digital pressure along the iliotibial band and vastus lateralis. The operator applies longitudinal stroking along the tissues for 6-10 repetitions.
2. **Piriformis Inhibition:** A muscle spindle massage technique. Starting at the origin/insertion of the muscle, utilize moderate to firm pressure and approximate fingers and thumb toward the middle of the muscle belly. Maintain a slow and steady rhythm to gradually cover the entire area of the muscle performing 4-6 strokes of a 1-2 second duration.
3. **Thoracic NAGS**: A passive accessory glide mobilization technique directed at the thoracic spine. Mobilization is performed in the posterior to anterior direction along the facet joint plane with the inferior vertebrae being mobilized anterior/superior on the superior vertebrae. Grade III/IV oscillatory mobilization is performed for 6-10 repetitions at each segment from T2-T8.
4. **Posterior Rib Mobilization:** Posterior to anterior mobilizations of the 2^{nd}-8^{th} ribs are performed using the heel of the palm to apply grade III/IV oscillatory mobilization for 6-10 repetitions at each segment.
5. **Latissimus Dorsi Release:** A soft tissue mobilization technique. The operator uses a skin rolling technique in the posterior axillary region in the area of the latissimus dorsi.
6. **Pectoralis Minor Inhibition:** A muscle spindle massage technique. Starting at the origin/insertion of the muscle, utilize moderate to firm pressure and approximate fingers and thumb toward the middle of the muscle belly. Maintain a slow and steady rhythm to gradually cover the entire area of the muscle performing 4-6 strokes of a 1-2 second duration.
7. **Anterior Rib Mobilization:** Anterior to posterior rib mobilizations are performed, focusing on ribs 3-5 (insertion for pectoralis minor), using the heel of the palm to apply grade III/IV oscillatory mobilizations for 6-10 repetitions at each segment.

People with limitations in thoracic spine rotation may be especially prone to certain types of shoulder and low back pathology since the thoracic spine is located within close proximity to those areas. For example, a pitcher who does not have full thoracic rotation may over extend and externally rotate the shoulder during the throwing motion in order to compensate for the lack of spinal motion. This alteration in pitching technique could cause excessive stress on the shoulder joint complex and lead to injury over time. The twelve segments of the thoracic spine contribute significant amounts of rotation and lateral flexion during functional activities such as pushing, pulling, throwing and lifting. Limitations in thoracic spine rotation may result in excessive movement in joints above and below this region. This excessive movement may lead to injuries frequently termed "overuse" in the literature, denoting tissues that are chronically inflamed. Once determined that a segment is "unstable" or hypermobile, conventional methods of evaluation and treatment often involve stabilizing or strengthening the affected area, the same area that is inflamed and "over used". In reality, it is possible that hypomobilities in areas largely designed for rotation, like the thoracic spine, may cause excessive motion in neighboring joints. In this instance, failure to correct the underlying impairment of a thoracic spine hypomobility could ultimately result in only a temporary decrease in these symptoms and lead to a recurrent problematic condition. By evaluating key areas of the movement system designed for rotation and then correcting limitations in these regions, proper biomechanics may be more fully restored which in turn may reduce the incidence of recurrent pathology. The thoraco-lumbar side lying rotation test and the thoracic sequence attempt to respectively evaluate and treat limitations in rotation in the thoracic spine and hips, two major areas of rotation in the human body.[8] These areas are bordered by the shoulder and lumbar spine; two areas of the body that are injured frequently during rotational activities such as bending/twisting and throwing.

Several limitations exist within this study. First, because this study was largely descriptive and conducted on relatively healthy, college-aged students, limited generalizations can be made. It is unknown if this STRM measurement would be reliable when performing measurements on a diverse population of people across ages, body types and sizes, and across the spectrum of diagnoses. Future research is needed to add to these preliminary results. Second, although this study revealed excellent intrarater reliability and good interrater reliability for using the STRM, the authors did not compare results to any criterion measure. Future studies comparing the STRM to measuring techniques used by Al-Eisa et al.[1] or using three dimensional motion sensors may add further validation to the STRM technique. Finally, apart from the reliability component of the research, the study was exploratory and no cause and effect conclusions can be drawn. This information, however, does serve to add descriptive data to the literature and should set the groundwork for further research in this area.

CONCLUSIONS

Because there was good intrarater and interrater reliability, the STRM could be used as an objective and reliable method to quantify thoraco-lumbar spine rotation. It also appears that a large percentage of patients with varied musculoskeletal complaints may have greater than a 10-20% asymmetry in spinal rotational movement. Future research is needed to determine the clinical applicability and relevance of these findings.

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